

Salt of Morphine-6-Glucuronide

This invention relates to a salt of morphine-6- β -D-glucuronide (M6G; see Figure 1) with improved stability, and to use of the salt as a medicament, in particular as an analgesic.

M6G is a metabolite of morphine which is known to be a more powerful analgesic than morphine itself and yet has fewer side effects. Methods of preparation of M6G are described in WO 93/03051, WO 93/05057, WO 99/58545 and WO 99/38876.

Whilst M6G base is stable when stored at -20°C, it does degrade when stored at room temperature. This degradation is not only noted by an increase in detectable degradation products, but also by a marked colour change of the compound. This will limit the shelf life of M6G base at ambient temperature.

It has now been found that the hydrobromide salt of M6G (M6G.HBr) is surprisingly stable compared to M6G base and other M6G salts, in particular the hydrochloride (M6G.HCl) and sulphate (M6G₂.H₂SO₄) salts. M6G.HBr showed a very limited amount of degradation and no discolouration after storage at room temperature for six years (see Example 1 below).

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According to the invention there is provided a hydrobromide salt of M6G (M6G.HBr). Methods of preparation of M6G.HBr are described in Examples 2 and 3 below.

30 M6G.HBr may be used as a medicament, in particular as an analgesic. Examples are for the treatment of moderate to severe, acute and chronic nociceptive pain (such as post-operative pain, pain associated with malignant and non-malignant diseases), and neuropathic pain.

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M6G.HBr may be administered by any suitable route. Examples are as a solid formulation (e.g. for oral, dry powder inhalation), as a solution formulation (e.g. intravenous (including infusion for

PCA), subcutaneous, intranasal, or sublingual), or as a transdermal formulation (e.g. by simple diffusion or by enhanced electrophoretic methods). Transdermal administration of pharmaceutically acceptable acid addition salts of M6G is 5 described in US 5,705,186.

According to the invention there is also provided a pharmaceutical composition comprising an analgesically effective amount of M6G.HBr together with a pharmaceutically acceptable 10 carrier, excipient, or diluent.

An analgesically effective amount of M6G.HBr will vary with the route of administration, and with factors such as the age, sex, weight, and condition of the subject being administered, and with 15 the type of condition being treated. In general, a suitable dose for an acute condition will be lower than for a chronic condition.

A suitable dose is in the range of 1-1000mg/70Kg, preferably 1-20 200mg/70Kg, more preferably in the range of 5-75mg/70Kg. A preferred dose for acute use is in the range of 5-75mg/70Kg. A preferred dose for chronic use is in the range of 30-500mg/kg. Dosage for routes of administration where bio-availability is 25 high (e.g. intravenous, subcutaneous, intranasal, sublingual) will be lower than for routes with low bio-availability (e.g. oral).

M6G.HBr may also be used for the symptomatic treatment of breathlessness in patients with advanced cancer. Any suitable 30 route of administration may be used, but a preferred route is inhalation of nebulized M6G.HBr. The effect of administration of nebulized M6G is described by Quigley et al (in *J. Pain Symptom Manage.*, Letters, Vol 23, No.1 (2002), pages 7-9). A dosage of M6G.HBr effective for the treatment of breathlessness in a 35 subject with advanced cancer will vary with the route of administration, and with factors such as the age, sex, weight, and condition of the subject being administered. A suitable dose

is in the range of 1-200mg/70Kg, preferably in the range of 5-75mg/70Kg.

There is further provided according to the invention a method of 5 making M6G.HBr which comprises: (i) contacting a hydrogen bromide solution with a solution of M6G in methanol; (ii) contacting the solution resulting from step (i) with an organic solvent to precipitate M6G.HBr; and (iii) isolating M6G.HBr precipitated in step (ii).

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Preferably the solutions and solvent are at -15°C, or below. This minimises formation of degradation products.

15 Preferably the precipitated M6G.HBr is washed to minimise the amount of organic solvent present. For example, the precipitated M6G.HBr may be washed with diethyl ether.

A preferred organic solvent is 2-propanol.

20 According to a preferred method a cooled diluted solution of HBr is added to a continuously stirred, cooled (to at least -15°C) solution of M6G in methanol. Then 2-propanol (or other suitable organic solvent) is added, and the resulting suspension is maintained below -15°C, while continuously stirring. Following 25 stirring of the suspension the resultant crystals are filtered and washed with a suitable solvent (e.g. 2-propanol or diethyl ether) and dried by suitable means (e.g. under vacuum at room temperature).

30 The following examples 1 and 2 relate to the stability of M6G salts at room temperature, and methods of preparation of M6G salts, respectively. Table 1 shows the stability data for the M6G salts tested, and Figure 1 shows the chemical structure of M6G and identified degradants. Example 3 relates to the stability of 35 M6G salts and base at 25°C/60%RH, 40°C/75%RH and 60°C. Tables 2-4 show the data relating to example 3.

Example 1 Stability of M6G salts at room temperature over 6 yearsAnalytical investigation by HPLC:

Samples of the hydrochloride salt (M6G.HCl) (205-2056), the 5 sulphate salt (M6G₂.H₂SO₄) (205-2060), and the hydrobromide salt (M6G.HBr) (205-2059) of M6G were stored at room temperature for almost 6 years and then analysed by HPLC. The results are shown in Table 1, together with the results of HPLC analysis of samples prepared under similar conditions a few months earlier.

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Results:

M6G.HCl (205-2056): The content of M6G decreased to 69% (starting from ~82%). HN-67002 and HN-67003 (which are typically oxidation products) increased to 1.3% and 2.1% respectively. The content 15 of HN-33177, a synthetic impurity of M6G, remained unchanged. However, there are 17 peaks present in the chromatogram that cannot be identified by retention time. The total of these impurities is 9.2 area %.

20 M6G₂.H₂SO₄ (205-2060): The content of M6G decreased to 63% (starting from ~77%). HN-67002 and HN-67003 increased to 1.1% and 1.8% respectively. The content of HN-33177 did not change. However, there are 13 peaks present in the chromatogram that cannot be identified by retention time. The total of these 25 impurities is 10.7 area % with a dominant peak at 23.5 min (6.55 area %).

M6G.HBr (205-2059): The content of M6G did not decrease at all and the content of HN-67002 (0.5%) and HN-67003 (0.2%) is much 30 lower than in the samples discussed above. There are only 4 additional peaks present in the chromatogram. None of these are bigger than 0.4 area %. The result is superior to the two other salts tested.

35 Conclusion:

The hydrobromide salt of M6G shows very limited degradation and was not discoloured after storage for six years at room temperature compared to the free base and other salts

investigated. Thus, the hydrobromide salt of M6G has improved stability at room temperature compared to the hydrochloride and sulphate salts of M6G.

5 Example 2 Preparation of hydrobromide and sulphate salts of M6G

Preparation of Q 3196 (M6G.HBr, 304-4428) :

4.99g of M6G.2H₂O were dissolved in 11ml of Methanol and cooled to -15°C. 1.16ml of HBr (48% in water) was diluted with 0.85ml of Methanol and cooled to -15°C and added slowly to the solution of M6G. A clear, highly viscous, pale yellow solution was obtained. The solution was stirred for 5 minutes before 100ml 2-propanol (-15°C) were added. The product precipitated immediately. The slurry was stirred for 3.5 hours at -20°C, the crystals were filtered off, washed with 37.5ml cold 2-propanol (-20°C) and dried at room temperature in a high vacuum. The yield was 5.61g.

Preparation of Q 3195 (M6G₂.H₂SO₄, 304-4429) :

20 5.02g of M6G.2H₂O were dissolved in 11ml of Methanol and cooled to -15°C. 0.35ml of H₂SO₄ (96%) was diluted with 0.85ml of Methanol and cooled to -15°C and added slowly to the solution of M6G. A clear, highly viscous, pale yellow solution was obtained. The solution was stirred for 5 minutes before 100ml 2-propanol (-15°C) were added. The product precipitated immediately. The slurry was stirred for 3.5 hours at -20°C, the crystals were filtered off, washed with 37.5ml cold 2-propanol (-20°C) and dried at room temperature in a high vacuum. The yield was 5.36g.

30 Example 3 Stability of M6G salts after 1 month at 60°C and 3 months at 25°C/60% relative humidity and 40°C/75% relative humidity

35 The analytical data below gives clear evidence that the stability of the hydrobromide salt is superior to all other salts assessed and in addition would appear to be more stable than Morphine-6-glucuronide base. The data demonstrates that the hydrobromide

salt is stable when subjected to storage conditions of 25°C/60%RH and 40°C/75%RH for 3 months and 60°C for 1 month. The base appears to be relatively stable to storage conditions of 25°C/60%RH after three months, but shows signs of degradation at 5 40°C/75%RH over 3 months and 60°C over 1 month.

All of the other salts show some form of degradation at 25°C/60%RH and at elevated temperature and humidity.

10 The Morphine-6-glucuronide sulphate salt is the least stable at 25°C/60%RH, whilst the Morphine-6-glucuronide hydrochloride is the least stable at 40°C/75%RH as this shows the greatest level of degradation of all the salts.

15 Introduction

Various salts and the base of Morphine-6-glucuronide have been subjected to storage conditions of 25°C/60%RH and 40°C/75%RH for 3 months and 60°C for 1 month.

20 The analytical testing comprised of:

- Visual appearance
- Water content (%w/w) by Karl Fisher analysis
- Assay (% w/w) and related substances determination
- 25 • Colour of solution by UV spectrophotometry.

The results obtained for each test were used to assess the stability of the various salts and the base.

30 Experimental procedures

Materials

Test Item Characterization, Sample Description

35 Six different salts of morphine-6-glucuronide were prepared from morphine-6-glucuronide base; the hydrobromide (HBr), sulphate (H_2SO_4), phosphate (H_3PO_4), hydrochloride (HCl), fumarate and maleate. The HBr salt was prepared by the method described in Example 2. The only difference was that after the 2-propanol slurry was filtered, the solid

was then washed three times with diethyl ether, before drying under vacuum at room temperature. This additional step was employed to remove as much 2-propanol from the salt as possible.

5 The other inorganic salts (sulphate, phosphate, hydrochloride) were prepared in a similar way, i.e. by addition of the relevant acid to a cooled stirring suspension of morphine-6-glucuronide base in methanol, trituration of the resultant solution with cooled 2-propanol to form a suspension, and then continuous stirring at low temperature. Filtration 10 of the solid is followed by washing with diethyl ether, and then drying at room temperature under reduced pressure.

15 The maleate and fumarate were prepared by the addition of the desired acid, on stirring at room temperature, to an aqueous solution of morphine-6-glucuronide base until all material was dissolved. The solution was then freeze dried to produce the required solid.

20 The same batch of morphine-6-glucuronide base (Batch M01003) was used to prepare each salt. This batch had been synthesised and tested to confirm identity, chemical and microbiological purity.

25 All salts prepared were tested to confirm appearance, assay (%w/w) by HPLC, confirmation of presence of correct counter ion, water content (%w/w) by Karl Fisher analysis, residual solvent analysis by GC and determination of colour of solution by measurement of UV absorbance of a 5 %w/v solution at 420 nm.

Description of Salts of Morphine-6-glucuronide:

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Description	Molecular Weight	Batch Number
M6G Hydrobromide salt M6G.HBr	542.37	JCCA24B
M6G Sulphate salt (M6G) ₂ .H ₂ SO ₄	1021.00	JCCA25B
M6G Phosphate salt M6G.H ₃ PO ₄	559.46	JCCA26B
M6G Fumarate salt (M6G) ₂ .Fumarate	1039.00	MM13A
M6G Maleate salt (M6G) ₂ .Maleate	1039.00	MM14A
M6G Hydrochloride salt M6G.HCl	497.92	MM10C

Description of Reference substances used in Testing of Salts:

Reference substance	Description	Batch number
HN-33169	M6G	401-2055
HN-33177	Synthetic impurity	401-2052
HN-75083	Degradant	401-2054
HN-75076	Degradant	401-2044
HN-67003	Degradant	401-2058
Morphine sulphate pentahydrate	Degradant	40IK1192

5 Each test material was stored between 2-8°C prior to placing on stability. Each material was sub-divided into 900mg aliquots, transferred to brown opaque HDPE plastic bottles and flushed with Argon prior to sealing. Sufficient samples were provided for each time point as well as spares for each storage condition. The 10 samples were placed in appropriate incubators previously commissioned at storage conditions 25°C/60%RH, 40°C/75%RH and 60°C.

15 The reference materials were stored under secure conditions at -20°C or below until required for testing.

Methods

20 The samples were stored for analysis according to the following table:

Storage Condition	Initial	5 months	9 months
25°C/60% RH	X	X	X
40°C/75%RH		X	X
60°C		X	-

X = Appearance, Water content by Karl Fischer analysis, Assay and Related Substances and Colour by UV /Vis spectrophotometry.

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Testing ProceduresTest for identity Content and Impurities

Testing was performed in duplicate (2 x 25mg) in accordance with

a stability indicating HPLC assay method. The assay results were reported as M6G as is, M6G as the anhydrous, solvent free material and the anhydrous solvent free material corrected for the salt form using the relevant conversion factor.

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Water Content by Karl Fisher Analysis

Water content was determined in duplicate on an aliquot of equilibrated material (approximately 100 mg) using a Tritrino 720 10 KFS Titrator.

Colour by Visible Spectrophotometry

A 5% w/v solution of test material was prepared in water and the 15 absorbance measured at 420nm in a 1cm silica cell using a Unicam UV4 Visible/UV spectrophotometer.

Results

20 These are shown in Tables 2-4.

Discussion

On storage for 3 months at 25°C/60%RH the hydrobromide, 25 hydrochloride, phosphate and base remain as white crystalline solids, the other salts showing varying degrees of colouration. However on storage at 40°C/75%RH over the same period, all the salts (except the hydrobromide) plus the base show signs of becoming yellow in appearance. The change in appearance is 30 reflected in the results for colour of solution, which increases in value as the yellow colour of the solid becomes more intense.

The general trend in moisture content is that the higher the storage humidity the greater the moisture content of the samples. 35 The exception however is the base, where the moisture content is reasonably consistent regardless of storage condition. Of the salts the largest change in moisture content is with the

phosphate (increase of around 8% at 40°C/75%RH compared to initial).

Review of the 3 month assay data shows some interesting trends.

5 The most stable materials (based on %w/w assay) are the hydrobromide, base and phosphate. It should be noted that the reason that the phosphate assay values are high throughout the study (around 110%± 5%), is that there were some problems in the preparation of this salt. These issues resulted in the material

10 being present as a mixture of phosphate/base in a ratio of approximately 10.8:1. The maleate and fumarate show a drop in assay of around 10% after 3 months at 40°C/75%RH compared to the initial values. Interestingly the hydrochloride shows a small decrease in assay after 3 months storage at 25°C/60%RH (around 6% compared to initial), however a dramatic reduction at 3 months

15 storage at 40°C/75%RH (approx 34% decrease compared to initial). This reduction is in fact more than that seen with the sulphate salt, which from the 1-month data alone was thought to be the most unstable salt. The low assay value seen at 3months

20 40°C/75%RH, may be linked to the breakdown of the crystal form at high humidity resulting in a high degree of degradation. This degradation is reflected in the amount of degradation products seen in this sample (total of around 54.5%)

25 Even after 3 months storage at 40°C/75%RH there is basically no increase in the amount of degradation products in the hydrobromide salt as measured by HPLC. At the same conditions, there is an increase of approximately 3% in the amount of degradation products in the base. The levels of degradation are

30 similar for the fumarate and maleate, slightly less for the phosphate. The least stable salts are the sulphate and the hydrochloride, with some indication that the hydrochloride is more stable than the sulphate at 25°C/60%RH, but the reverse being the case at 40°C/75%RH.

Conclusion

The results obtained indicate that the hydrobromide salt appears more stable than all other salts and the base. An overall review 5 of the data suggests the following order of stability:

Hydrobromide>base>>phosphate/maleate/fumarate>sulphate/hydrochloride

Table 1: Stability Data of M6G-Salts Stored at Ambient Temperature in Example 1

Salt	Batch	Elapsed Time (years)	Assay M6G uncorr.	Assay M6G corr.	HN-67002	HN-75076	Morphine	HN-75083	HN-67003	HN-33177	Unknown related substances (sum area %)
Hydrochloride	205-2042	0	82.2	88.7	---	n.d.	n.d.	< 0.1	---	0.3	<0.1
	205-2056	6	69.3	74.8	1.3	n.d.	0.2	n.d.	2.1	0.2	9.2
Sulphate	205-2041	0	77.2	93.6	---	n.d.	n.d.	< 0.1	---	0.2	0.2
	205-2060	6	63.3	76.8	1.1	n.d.	0.2	n.d.	1.8	0.3	10.7
Hydrobromide	205-2045	0	77.2	90.7	---	n.d.	n.d.	< 0.1	---	0.3	<0.1
	205-2059	6	81.9	96.3	0.5	n.d.	n.d.	n.d.	0.2	0.4	1.0
Free base	F12061	0	N/A	98.2	n.d.	n.d.	n.d.	n.d.	n.d.	0.7	<0.1
	F12061	5	N/A	81.2	n.d.	n.d.	0.3	n.d.	n.d.	0.8	11.8

n.d. not detectable

--- not investigated

5 M6G uncorr. content calculated as M6G base

M6G corr. content calculated as M6G derivative = M6G uncorr. x f

f = molecular weight (M6G-derivative) / molecular weight (M6G)

Table 2
Appearance, Moisture and Colour by Visible spectrophotometry: Example 3

Sample ID	Initial	1 month	2 months	3 months	4 months	5 months	6 months	7 months	8 months	9 months	10 months	11 months	12 months
Morphine-6-glucuronide sulphate	299615	Initial											
	307571	1 month	25°C/60%RH	White crystalline powder	3.77								0.136
	318587	3 months	40°C/75%RH	Pale yellow crystalline powder	4.28								0.244
	307578	1 month	40°C/75%RH	Slightly yellow crystalline powder	5.54								0.406
	318594	3 months		Slightly yellow crystalline powder	5.93								0.430
	307585	1 month	60°C	Pale yellow crystalline powder	8.31								1.056
Morphine-6-glucuronide hydrobromide	299616	Initial											
	307570	1 month	25°C/60%RH	White crystalline powder	2.38								0.029
	318588	3 months		White crystalline powder	2.56								0.073
	307577	1 month	40°C/75%RH	White crystalline powder	3.28								0.046
	318595	3 months		White crystalline powder	3.19								0.064
	307584	1 month	60°C	White crystalline powder	4.24								0.066
Morphine-6-glucuronide hydrochloride	299617	Initial											
	307565	1 month	25°C/60%RH	White crystalline powder	4.31								0.059
	318589	3 months		White crystalline powder	5.10								0.147
	307572	1 month	40°C/75%RH	Slightly yellow crystalline powder	6.06								0.253
	318596	3 months		Yellow crystalline powder	6.24								0.444
	307579	1 month	60°C	Pale yellow crystalline powder	9.02								2.107

continued

Table 2 (continued)

Designation	Laboratory Storage Condition	Storage Condition	Absorbance		Wavelength (nm)
			Initial	After 1 month	
Morphine-6- glucuronide fumarate	299618	Initial	25°C/60%RH	White crystalline powder	6.80
	307569	1 month	White crystalline powder	7.26	0.016
	318590	3 months	Pale yellow crystalline powder	8.00	0.034
	307576	1 month	Pale yellow crystalline powder	7.94	0.141
	318597	3 months	Yellow crystalline powder	10.89	0.264
	307583	1 month	Yellow crystalline powder	5.98	1.008
Morphine-6- glucuronide maleate	299619	Initial	60°C	Yellow crystalline powder	0.794
	307568	1 month	25°C/60%RH	White crystalline powder	6.14
	318591	3 months	White crystalline powder	7.53	0.017
	307575	1 month	Pale yellow crystalline powder	7.14	0.084
	318598	3 months	Pale yellow crystalline powder	7.60	0.209
	307582	1 month	Yellow crystalline powder	9.24	0.297
			60°C	Yellow crystalline powder	5.01
					0.879
					0.739

continued

Table 2 (continued)

Sample ID	Initial Condition	Storage Condition			Color	Crystalline Form
		25°C/60%RH	40°C/75%RH	60°C		
Morphine-6-glucuronide phosphate	299620 Initial	25°C/60%RH	White crystalline powder	3.12	0.034	
	307567 1 month	White crystalline powder	3.91	0.053		
	318592 3 months	White crystalline powder	5.06	0.098		
	307574 1 month	Slightly yellow crystalline powder	9.28	0.308		
	318599 3 months	Slightly yellow crystalline powder	11.88	0.878		
	307581 1 month	Pale yellow crystalline powder	5.12	0.787		
Morphine-6-glucuronide base	299622 Initial	White crystalline powder	9.80	0.017		
	307566 1 month	25°C/60%RH	White crystalline powder	9.00	0.040	
	318593 3 months	White crystalline powder	9.53	0.132		
	307573 1 month	40°C/75%RH	Pale yellow crystalline powder	9.68	0.182	
	318600 3 months	Yellow crystalline powder	9.85	0.630		
	307580 1 month	60°C	Yellow crystalline powder	8.21	0.541	

Table 3
Assay Example 3

ID	Batch No.	Storage Condition	Assay (%)		
			Initial	25°C/60%RH	40°C/75%RH
Morphine-6-glucuronide Sulphate	299615	Initial	80.62	88.49	97.87
	307571	1 month	73.58	81.82	90.51
	318587	3 months	69.08	77.05	85.24
	307578	1 month	65.04	73.67	81.50
	318594	3 months	59.39	68.38	75.64
	307585	1 month	57.15	63.84	70.62
Morphine-6-glucuronide hydrobromide	299616	Initial	82.26	83.63	98.29
	307570	1 month	83.02	85.18	100.11
	318588	3 months	84.30	86.19	101.30
	307577	1 month	82.40	85.09	100.01
	318595	3 months	83.14	85.85	100.90
	307584	1 month	82.82	84.44	99.25
Morphine-6-glucuronide hydrochloride	299617	Initial	81.63	93.28	100.65
	307565	1 month	79.21	92.03	99.30
	318588	3 months	75.48	87.71	94.64
	307572	1 month	69.13	81.39	87.81
	318595	3 months	51.00	61.41	66.26
	307579	1 month	65.73	75.78	81.76

continued

Table 3 (continued)

Descriptive Information	Sample ID	Initial Condition	Storage Condition			ANALYSIS RESULTS % VARIOUS BASIS
			25°C/60%RH	40°C/75%RH	60°C	
Morphine-6- glucuronide fumarate	299618	Initial				89.44
	307569	1 month	25°C/60%RH	81.96		88.23
	318590	3 months		81.20		87.15
	307576	1 month	40°C/75%RH	77.62		84.17
	318597	3 months		71.64		79.38
	307583	1 month	60°C	77.33		82.11
Morphine-6- glucuronide Maleate	299619	Initial				92.44
	307568	1 month	25°C/60%RH	83.61		88.28
	318591	3 months		80.27		86.66
	307575	1 month	40°C/75%RH	80.04		85.11
	318598	3 months		77.07		83.28
	307582	1 month	60°C	72.37		78.73
						88.63
						90.47

continued

Table 3 (continued)

Item No.	Reference No.	Storage Condition	UV-Vis Spectra		
			Initial	1 month	3 months
Morphine-6-glucuronide phosphate	299620	Initial	83.90		89.21
	307567	1 month	25°C/60%RH	84.57	91.37
	318592	3 months		84.25	91.16
	307574	1 month	40°C/75%RH	80.20	92.00
	318599	3 months		79.02	92.40
	307581	1 month	60°C	80.69	88.33
Morphine-6-glucuronide base	299622	Initial		91.07	99.79
	307566	1 month	25°C/60%RH	90.77	99.61
	318593	3 months		91.84	100.27
	307573	1 month	40°C/75%RH	89.94	99.45
	318600	3 months		88.67	97.15
	307580	1 month	60°C	89.31	96.18

Table 4
Related Substances: Example 3

Sample ID	Storage Condition	Initial			25°C/60%RH			40°C/75%RH			60°C		
		UV	IR	MS	UV	IR	MS	UV	IR	MS	UV	IR	MS
Morphine-6-glucuronide sulphate	299615	Initial	0.01	ND	0.15	0.69	0.23	1.08	0.64	1.72			
	307571	1 month	25°C/60%RH	ND	ND	0.69	0.63	0.27	1.59	2.70	4.29		
	318587	3 months		ND	0.17	1.36	0.52	0.53	2.58	6.58	9.16		
	307578	1 month	40°C/75%RH	0.06	0.21	1.58	0.50	0.74	3.09	6.69	9.78		
	318594	3 months		0.04	0.37	1.72	0.23	0.58	2.75	15.23	17.98		
	307585	1 month	60°C	0.26	0.72	2.73	0.23	0.61	4.55	13.70	18.25		
Morphine-6-glucuronide hydrobromide	299616	Initial		ND	0.04	0.72	0.10	0.86	0.08	0.94			
	307570	1 month	25°C/60%RH	ND	ND	0.74	0.03	0.77	0.07	0.07	0.84		
	318588	3 months		ND	ND	0.77	0.04	0.81	0.12	0.12	0.93		
	307577	1 month	40°C/75%RH	0.01	ND	ND	0.74	0.05	0.80	0.00	0.00	0.80	
	318595	3 months		0.02	ND	ND	0.70	ND	0.72	0.00	0.00	0.72	
	307584	1 month	60°C	0.04	ND	0.10	0.66	0.02	0.82	0.38	1.20		
Morphine-6-glucuronide hydrochloride	299617	Initial		ND	0.01	ND	0.63	0.06	0.77	0.47	1.24		
	307565	1 month	25°C/60%RH	0.04	ND	0.38	0.63	0.03	1.08	1.33	2.41		
	318588	3 months		ND	0.21	1.31	0.50	0.03	2.05	7.47	9.52		
	307572	1 month	40°C/75%RH	0.34	0.08	3.01	0.41	0.07	3.91	11.25	15.16		
	318595	3 months		1.67	1.55	3.71	0.07	0.01	7.01	51.57	58.58		
	307579	1 month	60°C	0.55	0.46	3.55	0.12	0.03	4.71	16.23	20.94		

continued

Table 4 (continued)

Sample ID	Storage Condition	Initial			25°C/60%RH			40°C/75%RH			60°C			
		UV	IR	MS	UV	IR	MS	UV	IR	MS	UV	IR	MS	
Morphine-6-glucuronide fumarate	299618	Initial	ND	ND	0.04	0.77	0.05	0.86	0.09	0.95	ND	ND	ND	
	307569	1 month	25°C/60%RH	ND	ND	0.80	0.03	0.83	0.08	0.91	ND	ND	ND	
	318590	3 months		ND	0.07	0.26	0.75	0.10	1.18	0.72	1.90	ND	ND	
	307576	1 month	40°C/75%RH	0.03	0.10	0.58	0.70	0.02	1.43	1.17	2.60	ND	ND	ND
	318597	3 months		0.40	0.45	1.56	0.57	ND	2.98	6.09	9.07	ND	ND	ND
	307583	1 month	60°C	0.06	0.24	0.97	0.62	0.02	1.91	1.94	3.85	ND	ND	ND
Morphine-6-glucuronide maleate	299619	Initial	ND	ND	0.04	0.76	0.05	0.85	0.00	0.85	ND	ND	ND	
	307568	1 month	25°C/60%RH	ND	ND	0.17	0.76	0.05	0.98	0.41	1.39	ND	ND	ND
	318591	3 months		ND	0.04	0.58	0.52	0.06	1.20	2.35	3.55	ND	ND	ND
	307575	1 month	40°C/75%RH	0.03	0.12	0.94	0.65	0.03	1.77	3.03	4.80	ND	ND	ND
	318598	3 months		0.40	0.43	1.68	0.50	ND	3.01	6.93	9.94	ND	ND	ND
	307582	1 month	60°C	0.14	0.32	1.20	0.50	0.02	2.18	3.91	6.09	ND	ND	ND

continued

Table 4 (continued)

Sample ID	Initial Concen. (mg/ml)	Storage Condition	HPLC Assay Results (mg/ml)			Total Loss (%)				
			Initial Concen.	1 Month Concen.	3 Month Concen.					
Morphine-6-glucuronide phosphate	299620	Initial	ND	ND	0.04	0.75	0.07	0.86	0.00	0.86
	307567	1 month	25°C/60%RH	ND	0.04	0.78	0.03	0.85	0.56	1.41
	318592	3 months		0.03	0.07	0.16	0.78	0.19	1.23	1.08
	307574	1 month	40°C/75%RH	ND	0.53	0.70	0.14	1.37	2.07	2.31
	318599	3 months		0.12	0.32	0.75	0.59	0.06	1.84	4.15
	307582	1 month	60°C	0.03	0.18	0.90	0.70	0.27	2.08	3.35
Morphine-6-glucuronide base	299622	Initial	ND	ND	0.05	0.87	0.06	0.98	0.00	0.98
	307566	1 month	25°C/60%RH	ND	ND	0.88	0.05	0.93	0.07	1.00
	318593	3 months		ND	ND	0.04	0.86	ND	0.90	0.52
	307573	1 month	40°C/75%RH	ND	ND	0.05	0.85	0.03	0.93	0.34
	318600	3 months		0.01	0.07	0.23	0.95	ND	1.26	3.08
	307580	1 month	60°C	ND	ND	0.19	0.83	0.02	1.04	1.27
										2.31